PUBLIC
S.F.
LIBRARY

MAIN LIBRARY

CALIFORNIANA

628.1 SA52 29601

NOT TO BE TAKEN FROM THE LIBRARY

Form 3427

Digitized by the Internet Archive
in 2010 with funding from
San Francisco Public Library

http://www.archive.org/details/reportsbyenginee00sanf

13 5 628.1 Sa 32

REPORTS

BY

ENGINEERS AND OTHERS

ON A

PERMANENT SUPPLY

OF

PURE FRESH WATER

TO THE

CITY OF SAN FRANCISCO.

SAN FRANCISCO
PUBLIC LIBRARY

SAN FRANCISCO:
Edward Bosqui & Co., Printers, Leidesdorff Street, cor. Clay.
1872.

REPORTS

ON THE

Supply of Pure Fresh Water

TO THE

CITY OF SAN FRANCISCO.

TABLE OF CONTENTS.

I. Certificate of Incorporation. - - - - - - Page 3

II. Engineer's Report of Preliminary Survey, - - - - 9

III. Report of Professor George Davidson, of U. S. Coast Survey, - - - - - - - - - - - 19

IV. Report of Special Committee to the Board, etc. - - 37

V. Engineer's Report of the Detailed Survey of Reservoir at the Pescadero. - - - - - - - - - 67

VI. Engineer's Report of Detailed Survey of the Great Storage Reservoir, at Canada Raymundo, - - 73

*628.1 Sa52

29601

CERTIFICATE OF INCORPORATION

OF THE

San Francisco Water Company

INCORPORATED JULY 22, 1867.

Certificate of Incorporation.

STATE OF CALIFORNIA,
City and County of San Francisco, } ss.

The undersigned, desiring to form a Company for the purpose hereinafter specified, do hereby certify that in pursuance of an Act of the Legislature, entitled "An Act to provide for the formation of Corporations for certain purposes." approved April 14th, A.D. 1853, and acts amendatory thereof and supplementary thereto, we have united ourselves, and formed a Corporation as follows, to wit:

The Corporate name of this Company is "THE SAN FRANCISCO WATER COMPANY."

This Company is formed for the purpose of supplying the City and County of San Francisco, and the inhabitants thereof, with pure, fresh water, for domestic, mechanical, and manufacturing uses and purposes, and of supplying any of the cities and towns near the route of the canals and aqueducts to be constructed by the Company, and the inhabitants thereof with the surplus of such pure, fresh water.

The Capital Stock of this Company is six millions of dollars, divided into and consisting of sixty thousand shares of the par value of one hundred dollars each.

This Company is incorporated for, and the time of its existence is, fifty years, from and including the date of this certificate.

The number of Trustees who shall manage the concerns and affairs of the Company for the first three months of its existence are three, and they are James T. Boyd, Milo Hoadley, and John H. Turney, all of whom are citizens of the United States and residents of the State of California.

The principal place of business of this Company is to be located in the City and County of San Francisco, in the State of California.

In witness whereof, we have hereunto severally set our hands and seals, at the City of San Francisco, this twenty-second day of July, in the year of our Lord one thousand eight hundred and sixty-seven.

JAMES THOS. BOYD, [L.S.]
JOHN H. TURNEY, [L.S.]
WM. H. HANFORD, [L.S.]
MILO HOADLEY, [L.S.]

Signed, sealed, and
delivered in presence of

STATE OF CALIFORNIA,
City and County of San Francisco, } ss.

On this twenty-second day of July, A.D. one thousand eight hundred and sixty-seven, before me, T. A. Lynch, a Notary Public in and for the said City and County, duly commissioned and sworn, personally appeared the within-named James T. Boyd, John H. Turney, William H. Hanford, and Milo Hoadley, whose names are subscribed to the annexed instrument as parties thereto, personally known to me to be the individuals described in, and who executed the said annexed instrument, and they severally and duly acknowledged to me that they

executed the same freely and voluntarily, and for the uses and purposes therein mentioned.

In witness whereof, I have hereunto set my hand and affixed my official seal, the day and year in this certificate first above written.

T. A. LYNCH,
Notary Public.

ENGINEER'S REPORT

Of the Preliminary Survey of the

San Francisco Water Works,

FROM

PESCADERO CREEK

TO THE

CAÑADA RAYMUNDO.

REPORT.

To the Corporators of the
San Francisco Water Works—

GENTLEMEN: In obedience to your instructions and after organizing a party with the necessary assistants, we proceeded, August 1st, 1867, to the Cañada Raymundo, running a line of levels up the San Mateo, from tide water to determine the elevation of the valley, and also for a closing point for our work.

August 2d was occupied in exploring the country and reaching the scene of our future labors on the Pescadero; and on Saturday, August 3d, we located the dam and commenced the line of the aqueduct, a map of which accompanies this report.

Our line (from the dam) passes down the north bank of the Pescadaro, cutting across several projecting points, and running through a heavy growth of redwood timber and thick underbrush—making it impossible to determine where we should go, or, what was the character of the country in advance.

At Station 169 we crossed Tarwater Creek, (a tributary of the Pescadero), and projected our line over the ridge to the South Fork of the San Gregorio Creek, at Station 295, in order to ascertain its elevation; and, finding it at this place too high for our purpose, we commenced back at Station 255, and ran a line down the ridge to near Jones' house; and from this point, again

crossed the ridge, striking the South Fork about three-quarters of a mile above its junction with the main San Gregorio or Woodhams Creek.

The line between Tarwater and Jones creeks has not been surveyed, as it was deemed unnecessary for the present—being of the same character as regards soil, bed-rock, and timber, as that portion of the line between the dam and Tarwater Creek ; and the same proportions were used in making up the estimates.

In crossing Jones Ridge, from the Pescadero to the San Gregorio valleys, a tunnel will be required one hundred and fifteen chains in length. The hill is of soft sandstone, and the tunneling can be done nearly as cheap as the same distance could be constructed in any other manner, as we will dispense with all clearing, fluming, or pipe. There are also several short tunnels required on the line before reaching Jones Creek, to which we deem it unnecessary to call your special attention, as they are all included in the general estimate. From the lower end of the tunnel through Jones Ridge, our line follows the bed of the South Fork of the San Gregorio to Station 385, where we propose to put in a dam, and take up the waters of the creek. From this dam we continue down the north bank to the main San Gregorio or Woodhams Creek, which we cross at Station 428, with an elevation of seventy-five feet above its bed.

Thence, following down the north slope of the main creek, with several short tunnels through projecting points, we cross Rays Creek, at Station 554, with sixty-four feet elevation.

At Station 507 we first leave the heavy redwood timber, and except in the creek bottoms we do not again encounter it.

From Rays Creek we follow the grade around the hillside to Bogus Creek, which we cross at Station 588, with

one hundred and twenty feet elevation ; and following along the steep hillside with several tunnels of moderate length, we cross Keefers Creek, at Station 718, with an elevation of seventy feet ; thence by another tunnel at Alamo Creek, and up along its east slope, crossing it at Station 746, and one hundred and ninety feet above it.

Our line then runs to the Corte Madeira, by a tunnel through the ridge dividing the same from Alamo, and following up the east slope of the Corte Madeira, crosses several deep ravines (requiring high flumes), to Station 894, from which point we cross the creek at Station 904, with an elevation of one hundred and twenty-six feet, and striking Raynors Ridge, tunnel through it to Allens Ravine. A line was also run for one and a half miles up the bed of the Corte Madeira, but was foumd impracticable, and abandoned.

From this point we cross the Dry or South Fork of the Tornitas, by two tunnels ; but this portion of the line can be modified to only one—shortening the distance and decreasing the cost.

We crossed the Dry Fork of the Tornitas at Station 1064, with an elevation of eighty feet, and turning through Downings Ridge, reach the Middle Fork, at Station 1156, crossing it two hundred and five feet above its bed ; thence through the ridge to the North Fork, which we cross at Station 1203, with sixty feet elevation.

Our line then continues through Irish Ridge to Lobitas Creek, and crossing it sixty-seven feet above its bed, continues to the valley of the Purissima, which we cross near the house of Maj. Bowman, with sixty-five feet elevation. Another line was run between the Lobitas and Purissima, but was afterwards abandoned.

From the Purissima we tunnel into the Cañada Verda, crossing the South Fork at Station 1534, with ninety feet, and the North Fork, at Station 1625, with one hundred

feet elevations, and by another tunnel reach the Cañada Leon, at Station 1724, and one hundred and thirty-eight feet above its bed.

We then follow grade up and along the steep side of the valley to Station 1779, when we tunnel through the ridge to the valley of the Pilcarcitos ; up and along the south slope of which, we continue our line until we reach the main divide at the head of the valley, when, by another long tunnel, we enter the Cañada Raymundo.

Various modifications and alterations have been made (which are shown in the map in red), and will both shorten and cheapen the work ; and we are of the opinion that still further alterations can be advantageously made. This, however must be left for future surveys to determine.

A considerable amount of clearing will be necessary above the dams on the Pescadero and South Fork of the the San Gregorio ; and the timber cut will furnish all that will be required in the construction of dams, over falls, or any other purposes, in the immediate vicinity.

The brick needed for the construction of the works can all be made near the line, as there is plenty of good brick-clay and wood to be obtained along the entire distance.

Freights can be transported by rail to the several stations along the San Jose Railroad, and can be delivered on the line cheap from these points, as wood and lumber teams all go that way empty.

The dimensions of the tunnels are estimated at thirty-four feet of cross-sectional area ; and to be lined where required, to be cut true and to the proper grade.

The estimated lengths of tunnels required will be 81,551 feet, or a trifle over fifteen and a quarter miles, a large portion of which will be through soft sandstone, and can be cut nearly as cheap as the work could be exe-

cuted in any other manner; and, until we reach the valley of the Pilcarcitos, in no case is hard rock encountered on the line. Estimates have been made to include the lining where required, and for face walls at the entrance and exit of each tunnel.

The whole cost of tunneling is estimated at $793,022, and will, when finished, be the most substantial portion of the works.

For the balance of the distance, two estimates have been made—one for a wood flume, and one for an iron pipe.

1st. *For a Wood Flume.*—The flume to be four feet square in the clear, having an area of sixteen feet, which, with the descent (two feet to the mile), will carry with safety 25,000,000 gallons daily.

The flume to be laid upon a graded bed, or set upon trestle work of sufficient strength, and to be well braced and stayed where required.

The whole work will cost when completed, including dams, tunnels, flumes, and all work necessary to be done in order to bring the water of the Pescadero into the Cañada Raymundo, $1,209,397.

2d. *For an Iron Pipe.*—The pipe to be circular, five feet in diameter, with an area of 19.62 feet. To be laid on the ground and covered, with the necessary manholes, blow-cocks, etc.; to be made of rolled iron, and rivited together; the whole to be of sufficient strength to sustain the required pressure; and the ends to be bricked in the tunnels far enough to preclude the possibility of a cave or any accident whatever.

This will be a much more permanent mode of construction than a wood flume; will require no tending; will be in no danger from fire or falling timber; and, being buried, will not damage property in any manner whatever. There will be no waste from leakage or

evaporation; and the water will be delivered cool, sweet, and clean at the terminus.

The whole cost, with tunnels, etc., as included before, will be $1,446,444, or $237,047 more than the wood flume.

With only this difference of cost in a work of as much magnitude as that about to be undertaken by you, we would earnestly recommend the use of iron in every case, and exclude wood and all other perishable materials whatever in its construction.

The object of this survey was not for the purpose of making an accurate location, but to ascertain the practicability and the probable cost of bringing the water from the Pescadero into this city; and it was deemed unnecessary to extend the line beyond the Cañada Raymundo, as from this point surveys had been made, and the feasibility of the undertaking had been determined.

The streams discharging into the ocean between Half Moon Bay and Point Año Nuevo, are the only source from which San Francisco can be supplied at any reasonsonable cost; and we have no hesitation in giving it as our opinion, that the whole will be required within the next fifty years.

The amount of water which they will furnish has never been accurately ascertained, and, except on the Pescadero, no measurements have been taken. This stream, however, gives, in the dryest time, about 5,000,000 gallons daily, and for eight months in the year, will fill the aqueduct, *i. e.*, 25,000,000 gallons; and by a judicious system of reservoirs along the line, we will be able to furnish for use, 30,000,000 gallons daily.

The water can be brought into the city at an elevation of two hundred and fifty feet above tide; and the quantity used below one hundred and fifty feet, will furnish the necessary power for raising all that will be required above the 250-foot level.

Hoping that the map and estimates, herewith submitted, will meet with your approval,

I remain,

Your obedient Servant,

MILO HOADLEY,
Engineer in Charge of the Survey.

San Francisco,
October 26, 1867.

REPORT

OF

PROF. GEORGE DAVIDSON,

OF THE

U. S. COAST SURVEY,

MARCH, 31st, 1869.

San Francisco, (Cala.), March 31, 1869.

To William Burling, Esq.,
President San Francisco Water Co.,
San Francisco:

Dear Sir:

In accordance with your request, I have made a general examination of the country between the Cañada Raymundo and the Pescadero, for the purpose of determining its capability of furnishing a sufficient supply of good water for the city of San Francisco, and the feasibility of bringing that supply to the city.

Proposed Sources of Supply.

The geographical position of San Francisco is such, that the localities capable of supplying it with water are naturally limited, and readily defined.

Clear Lake and Lake Tahoe have been suggested as available, but apparently for the sole reason that the supply is large and the elevation great. The former is 80 miles in a straight line from San Francisco; the latter 150; and both would have to cross the Bay of San Francisco. While it is a maxim of engineering, that nothing is impracticable with skill, time and money, yet the proposition to bring the water from these distances, borders on the chimerical.

Could a supply, with the necessary elevation, be procured from the Peninsula of Tamalpais, between Bodega Bay and the Golden Gate, it would have to be carried under the Golden Gate.

The same is essentially true of any supply from the Contra Costa range ; it would have to cross the bay.

The Peninsula of San Francisco the Natural source of Supply.

Leaving these distant and doubtful sources of supply out of the question, the one nearest the city, with a large area of catchment, and a large rain-fall, is upon the Peninsula of San Francisco, between the Golden Gate and the Bay of Monterey. For the purposes contemplated in this report, the Peninsula may be considered as stretching from Fort Point to Monterey Bay. The northern part is very narrow, comparatively low, irregular, and broken and drained by small streams, inadequate for supplying a large city. Ten miles south of Fort Point, the surface features assume well marked and broad generalizations. Eight miles south of Point Lobos, the main ridge of the San Francisco Peninsula, commencing abruptly on the sea shore, with an elevation of 720 feet, stretches 75 miles in nearly a straight line to the Pajaro river, emptying into Monterey Bay. This ridge is the water-shed of the waters flowing into the west side of San Francisco Bay, and into the sea. The general direction of this peninsular backbone, is northwest and southeast (true), and from its northern extremity, it gradually leaves the seashore. Abreast of Point San Pedro, it is about midway between the bay and ocean, and 3½ miles from either. At Black Mountain, 30 miles from Laguana Alta, it is 9 miles from the low, flat, bay shores, and 18 miles from Point Año Nuevo. As it stretches southward, it rises regularly, and obtains an elevation of 2,809 feet, in 32 miles, at Black Mountain, at the head of the Pescadero and San Lorenzo ; and reaches its greatest elevation, 3,791 feet, in 55 miles, at Mount Bache, at the head waters of the Gatos, flowing into Guadalupe, and the

Corralitos, flowing intõ the Pajaro: thence the elevation decreases to the great valley, stretching eastward from Monterey Bay. This ridge, and these elevations, should be specially borne in mind, as they have a very important bearing upon the water supply of this Peninsula.

On the San Francisco Bay, or east side of this ridge, the hills have a very rapid fall to the low country bordering the bay; on the ocean side, long spurs between the valleys of the streams, stretch toward the ocean in well-sustained elevations, forming bold headlands. But the descent into the cañons, at the head of the numerous branches of the Pescadero and San Gregorio, is sharp.

On the bay side, the streams have short courses and comparatively small area of catchment, within the elevation required to carry the water by gravitation to the city. The San Mateo and San Francisquito are the only streams of any importance on the bay side, within reasonable distance of the city.

On the ocean side of the ridge, south of the line joining San Mateo and Half Moon Bay, are the Pillarcitos, Purissima, Tunitas, San Gregorio and Pescadero; and further south, the Butano, Año Nuevo, Jarro, San Lorenzo, etc. As we advance southward from the Pillarcitos, the streams have a greater breadth of the Peninsula to traverse, are larger and more generally bordered with a heavy growth of timber. On the San Gregorio, Pescadero and San Lorenzo, redwood and yellow pine, of enormous growth, fill the valleys.

This growth of timber has an important influence upon the supply of water, hindering rapid drainage in great and sudden rains, and preventing evaporation in the dry season.

The latter is, perhaps, counterbalanced by the supply of moisture necessary to meet the demands of this vege tation.

The country is well settled; all the untimbered land is under cultivation, or used for grazing. Numerous saw-mills are found upon the various streams, and the timber transported across the ridge to the bay shores.

Incidentally, I may mention that, on the San Gregorio, I measured a redwood tree, 26 1-3 feet in circumference, at 6 feet above the ground, and reaching a height of 270 feet; while hundreds of trees were passed, averaging nearly 6 feet in diameter. Yellow pine were seen over four and five feet diameter, and estimated at 200 feet in height. I measured a fallen one; it was nearly five feet in diameter, and 180 feet long.

General Examination of the Coast to Pescadero.

The country you desired me to pass over, was from the northern part of this peninsular ridge to the waters of the Pescadero; and in the execution of that work, I examined the San Andreas Valley to the confluence of that stream with the San Mateo and the Lake Creek.

Following the western side of the Peninsula, I crossed the Purissima, ascended the Tunitas, and passed over the line of the preliminary survey to the ridge; descended the main north branch of the San Gregorio to the foot of Raynor's ridge, about 176 feet above the sea; ascended the main stream to its northeast head, and followed the peninsular ridge to the head waters of the Pescadero, descending the Peters branch to the confluence of the Peters branch with the Pescadero.

In regard to distances and levels, I was guided by the U. S. Land Surveys, by the preliminary surveys for this work by Mr. Hoadley, and by his personal explanation at the localities visited.

On the route, I found his marks and benches, and have no reason to doubt that it was faithfully done over a country very abrupt, with thick chapparal on the slopes and with much forest.

Necessity for a Detailed Survey.

Before the location of the Conduit route, and of the dams can be established, and before proper estimates can be made of the cost of the undertaking, a detailed and exhaustive survey will be necessary of the whole route. This will be difficult, because part of the country around the Pescadero and San Gregorio is densely over-grown with chapparal and forest.

For such a survey, the preliminary one will serve as a general indication of the route, and give a fair proportion of the amount of tunneling, etc. The contouring for a belt one mile wide should be put in ; the formation of the rock examined. The measure elevation of the proposed dam on the Pescadero should be checked by a line of levelings run therefrom, down the Pescadero to the sea.

Climate, Rain-fall, etc.

The climate of the California Coast is so peculiar that the general ratios of rain-fall and drainage established for the Atlantic Coast of the United States, and the great basin of the Mississippi cannot be taken here.

Our rains commence in October and end in May ; during the summer months the fall of rain is exceptional, but the evaporation along the seaboard, is retarded by the very heavy fogs which prevail in the " dry season ;" their effect is well known upon the grazing ranchos of the coast; during their prevalence vegetation is drenched as with a fine rain. I have before determined by observation that our coast fogs attain an elevation averaging about 1,500 feet, and sometimes 1,700 feet above the sea. But a remarkable fact demonstrated by observation is this : that the rain-clouds which come from sea ward and strike the western flank of the great peninsular ridge, yield from two to three times as much rain-fall as is

measured on the eastern or bay flank of the ridge. The farmers and lumbermen roughly estimate it at three times the rain-fall of San Francisco, and observation confirms their judgment.

The fall of rain at San Francisco in the winters of 1864 and 1865 was respectively 24.7 and 22.9 inches; while the observations at the Pillarcitos Reservoir gave rain-fall of 53 and 58 inches, or an average of 2.3 times the fall in San Francisco. Considering the greater elevation of the ridge at the Pescadero; the dense and large growth of timber there, and remembering that Pillarcitos has a high ridge to the westward of it, we may safely assume that the fall of rain on the Tunitas, Purissima, San Gregorio, and Pescardero is $2\frac{1}{2}$ times the amount in this city. The average annual rain-fall at San Francisco, obtained from twenty years observations is 24 inches. Hence, the rain-fall on the Pescardero is 60 inches or 5 feet. This would give 139,392,000 cubic feet of water for each square mile of catchment. Part of the country is high, with cultivated ridges and sharp valleys. On the steep slopes the rain-fall would drain rapidly; but where it is covered with chapparal or timber, the drainage would be slow. In very heavy and sudden rains much of the rain-fall will be lost, but in the moderate and light rains, especially such as fall in very dry winters, nearly all will be utilized. Without actual observations, but upon a careful weighing of all the causes at work, we may safely assume that for the driest seasons, fully six-tenths of the rain-fall can be utilized.

Area of Catchment, Supply.

The area of catchment of the different streams above the points where their supplies are gathered, is so well defined by the ridges and dividing spurs, that for our purpose the surveys of the U. S. Land Office may safely be taken as correct.

Commencing at the southward the first stream is the *Pescadero.* The area of catchment of this stream above the proposed site of the dam is 30 square miles.

Tarwarter Creek. This is avoided as the water is impregnated with petroleum.

San Gregorio—South Fork, 5 miles; North Fork and tributaries, 13 miles; Bogus Creek and Alamo, 6 miles; Main Branch, 6 miles.

Tunitas, 6 miles.

Purissima twelve miles, but this is not considered good water. If collected above the Sulphur Springs it might prove all that was needed.

Lobitas, *Canada Leon*, *Canada Verda*, would supply about 5 square miles, but are not relied upon. *Canada Raymundo* 18 sqare miles. The amount of rain-fall for this valley is taken the same as that of San Francisco.

While it is interesting to know the average supply that the above areas of catchment will afford, as exhibited in the following table. Yet the supply for this must be based upon the mininum rain-fall of any one season. In this table we assume that the amount of rain-fall utilized is only six-tenths of the whole fall. This is less than the average of 17 places given for Great Britain, and less than some of the localities in the United States.

Water Supply from the Pescadero, etc., with average Annual Rain-fall.

Basin.	Area of catchment Miles.	Cubic feet—yearly.	Gallons yearly, 7¼ gallons to a cubic foot.	Gall's daily.
Pescadero	30	2,509,056,000	18,190,656,000	49,837,414
San Gregorio South	5	418,176,000	3,031,776,000	8,306,213
San Gregorio North	13	1,087,257,600	7,882,617,600	21,596,237
" Bogus & Alamo	6	501,811,200	3,638,131,200	9,967,482
Tunitas	6	501,811,200	3,638,131,200	9,967,482
Canada Raymondo	18	602,172,240	4,315,748,740	11,960,956
Totals	78	5,620,284,240	40,747,060,740	111,635,784

The "rainy season" of 50–51, was the driest on record. There was measured in San Francisco a fall of a little less than one-third of the average fall of twenty-four inches. Assume the fall at one-third, or 8 inches, and that the ratio of fall west of the ridge, with that east of it was the same as that already stated; let the amount utilized be also the same, we should then have the following exhibits.

Water Supply from the Pescadero, etc., during the Least Annual Rain-fall on Record.

Basin.	Area of catchment Miles.	Cubic feet—yearly.	Gallons yearly, 7½ gallons to a cubic foot.	Gall's daily.
Pescadero.....	30	836,352,000	6,036,552,000	16,612,471
San Gregoria South.....	5	139,392,000	1,010,592,000	2,768,745
San Gregoria North.....	13	362,419,200	2,627,539,200	7,198,737
" Bogus & Alamo	6	167,270,400	1,212,710,000	3,322,494
Tunitas.....	6	167,270,400	1,212,710,400	3,322,494
Cañada Raymundo... ..	18	175,633,920	1,273,345,720	3,488,619
Totals...., ...	78	1,848,337,920	13,400,449,920	36,713,560

These tables establish the fact that, while the area of catchment furnishes an average of 111,000,000 of gallons daily, in seasons of average annual rain-fall, yet in such a dry season as has actually occured within the last 20 years, the average supply has been as low as thirty-six millions.

Without a thorough and systematic gauging of the streams for one or two years, under different conditions of rain-fall, it is difficult to decide upon the daily supply of any one at the driest time of the driest seasons. Our estimate of the amounts utilized, are believed to be below, rather than above, the actual conditions.

From the concurrent testimony of farmers, and occupants of land upon some of the streams, the Corte Madera, at Laytons, furnishes, in September of dry seasons,

one-half the amount running at the time of my visit, which was in March, after 35 days of dry, clear weather, following a measured rain-fall of only 16 inches to that date in San Francisco. An approximate measuring of the Corte Madera, gave over six millions daily. I found evidences that, after sudden, heavy rains, the stream increases to six feet in depth, and about twenty feet in width. On the San Gregorio, an approximate gauging gave over ten millions daily; and, after sudden, heavy rains, it increases to a stream over six feet deep, and 40 feet wide.

On the Pescadero, at the site of the proposed dam, the approximate gauging gave from fourteen to fifteen millions of gallons daily. This stream, from the great amount of timber upon its banks, maintains a more uniform and regular supply; but in heavy, sudden rains, it increases largely in depth.

If we suppose that the San Gregorio and Pescadero supply only one-half the above amounts in September of a dry season, we should have a daily supply of fifteen millions of gallons, without any reservoir.

With the certainty of such a supply, it could be brought directly across the Cañada Raymundo, and thence to the city, while a great reservoir was being built.

Necessity for a Storage Reservoir.

If this, exceptionally, dry season of 1850–'51, were followed by a summer with few fogs and strong winds, the evaporation would be greater than the average, the demands of vegetation would be greater, and the computed minimum supply of thirty-six millions would be decreased. For the present population, it would be largely in excess of the demand, and no reservoir would be needed immediately. But for a rapidly increasing population, for manufacturing demands increasing in

greater ratio than the population, and to guard against accidents upon the work, a large reservoir should be established.

Storage Reservoir.

To provide against all contingencies of supply, a great storage reservoir is necessary. The most available one appears to be that which can be found in the Cañada Reymundo, 22 miles from the Pescadero, and 21 miles from Portsmouth Square. The area required to store 300 days supply of 40,000,000 gallons daily, would be 1,542 acres, with a depth of water of 25 feet. This area, I judge, can be got by building a dam across the outlet of that valley at or near the confluence of the San Mateo and Lake creeks. I have no doubt of the feasibility of building such a dam, but its exact location, structure, form and height must be determined by a detailed survey. At the bridge below the Crystal Springs, the elevation above tide is 160 feet, and a dam of 150 feet, at or near this point, would form a reservoir of large extent. This reservoir would be near the centre of the 18 mile area of catchment of the Cañada. As thriving farmers cultivate every available acre of this Cañada, the question of damages, and of clearing arises, but I have not been asked any opinion thereon.

Without an actual survey of the water line of the Cañada at the level proposed, the area available cannot be stated, but I judge it even more than requisite. This storage reservoir is necessary on account of the long dry seasons of this coast, especially after unusually dry winters; to guard against accidents; to supply power etc.

Line from the Pescadero, etc.

There will be no engineering difficulty in building a dam at the Pescadero, but it must be constructed to

withstand not only the effects of sudden rises in the stream, but the drifting timber that necessarily drives down at such times. With a dam 50 feet high, the surface water will be 394 feet above the tide, and the distance to the Cañada Reymundo not less than 22 miles.

From the configuration of the spurs stretching from the Peninsula ridge to the ocean, and the very heavy timber in the valleys of the Pescadero and San Gregorio, a large proportion of the line must necessarily be tunnelled. The preliminary survey gives no less than 96,000 feet in twenty-seven tunnels, varying from 726 feet, to 7,854 feet. I think that a detailed survey would develop much less tunneling, and in most cases tend to shorten the lines of tunneling. But the above lengths indicate the practibility of carrying on the work of tunneling at many points at the same time. Where timber is heavy it will be safer and probably cheaper to tunnel than to follow the grade around a timbered hill-side.

On the steep hill-sides that are only covered with grass, there will be much tendency to wash in heavy rains; and some difficulty in conveying materials.

The material of the spurs and ridges seems to be an easily worked sand-stone, which in many places at the surface can be worked with the pick. Only near the Pillarcitos is seen an exposed cropping of granite.

This granite is seen further northward along part of the road cutting from Crystal Springs to Half Moon Bay.

For such an expensive work, temporary flumes of wood cannot be recommended; and it would jeopardize the work at any moment to pass the water through tunnels not lined. Moreover, the experiments at the Washington Aqueduct prove that the rough unlined tunnel delivers only 79 per cent. of water, that a lined tunnel of even smaller section.

The line should be a brick conduit of circular section, the bricks moulded to the section, and laid with as thin a layer of cement as practicable. And the interior face of the bricks should be glazed. When the aqueduct passes along the face of hill-sides it should be built so deep that the top can be covered with not less than two or three feet of soil.

If an examination of the area of catchment of the San Lorenzo should demonstrate that a large additional supply can be practicably added to that from Pescadero, San Gregorio, etc., the dimensions of the aqueduct should be built with a view to that additional supply.

Supposing the slope of the aqueduct from the top of the proposed dam of 50 feet at the Pescadero, (394 feet above tide), to the surface of the storage reservoir at the Cañada Raymundo, (300 feet), to be three feet per mile, and that aqueducts of the following dimensions carry a body of water whose surface is two feet above the centre of the aqueduct, then the amount carried daily by each will be as follows :

Aqueduct of	7	feet internal diameter	55,000,000	gallons
"	8	" " "	72,000,000	"
"	9	" " "	91,500,000	"

After consideration of the area to be drained, the amount of rain-fall, the peculiarity of the seasons, the topography of the country, and the prospective addition of the waters of the San Lorenzo, I think the aqueduct should not be less than nine feet in diameter.

Estimates.

I refrain from making any estimates for damming, tunneling and building, without a detailed survey. The dams required first would be on the Pescadero, San Gregorio and Corte Madera ; and for the storage reservoir. All others may be dammed as their waters are

needed. Nor have I made any estimates of damages, as not coming within your instructions. They must, however, be very small until the storage reservoir is reached.

The Character of the Waters.

I have placed, for analysis, waters of the Pescadero and Corte Madera, and the results will be communicated when received. So far as taste and appearance are concerned, those of the Pescadero are clear and pleasant; of Peters branch, discolored by redwood sawdust and slabs from a sawmill; of San Gregoria, clear and pleasant; of Corte Madera, dark and unpalatable; of the Tunitas, one branch was discolored by a recent land slide, and the other by redwood sawdust. The Purissima is, by common report, clear, but when kept standing for a few days, becomes stringy. It may prove good above the Sulphur Springs, situated about a mile above the proposed crossing. The redwood refuse from the mills discolors the water and drives out all the fish.

The soil on the whole range is rich—in some places quite "adobe"—and exhibiting slight "alkali" deposits on the surface. Towards the Pescadero, the soil changes from a dark to a lighter color.

Resume.

The area of catchments, drained by the proposed line, and by the storage reservoir, is 78 square miles.

The area of catchments of the Butano, Año Nuevo, San Lorenzo, etc., is larger than that of the Pescadero, but we have no levelings upon either stream.

The computed daily drainage for an average rain-fall, is one hundred and eleven millions of gallons daily.

The computed daily drainage for a rain-fall of the driest season recorded, is thirty-six millions of gallons daily.

The actual gaugings (approximate) of the Pescadero, San Gregorio, and of its branch, the Corte Madera, after a thirty-five days' drought, in 1869, was thirty millions of gallons daily.

The storage reservoir should hold a supply for 300 days' consumption, at forty millions of gallons daily, with a surface elevation of 300 feet above tide.

The position on the Pescadero is favorable for a good dam. If built 50 feet high, the surface water will be 394 feet above tide, and back the waters up Peters branch about half a mile, and further up the Pescadero. The fall to the storage reservoir is about three feet to the mile.

Dams are necessary at the San Gregorio and Corte Madera. I did not visit the proposed localities where the aqueduct is carried across ravines or deep beds of smaller streams: the supporting must be made to withstand the occasional driving of heavy trunks of trees in heavy rainstorms.

The distance from the Pescadero dam to the Cañada Raymundo cannot be less than 22 miles, and will be more if much tunneling is avoided. About 18 miles may have to be tunneled. This tunneling appears to be generally through easily-worked sandstone, as shown by the outcroppings and the recent cuttings for roads on steep hillsides. On the roads, all the material was worked with the pick. Prof. Whitney, late State Geologist, gives an accurate description of the geology of this section.

The tunnels would be in such lengths, that not less than fifty places on the whole line can be worked at the same time. Hundreds of miles of much heavier tunneling are found throughout our mining region; and an abundance of labor, skilled in such work, can be readily commanded at about $3 per day. The country will easily support large bodies of workmen.

Material for making brick exists near all parts of the line. Wood, for burning, is plenty.

Heavy timber, for carrying temporary flumes over streams and gullies, is plenty and readily obtained.

Materials from San Francisco can be carried from the line of the San José Railroad, by wagons, over the ridge, at an elevation of about 1,400 feet, at the head of the Pescadero.

Approximate estimates may be made for the aqueduct for 22 miles in length, and for dams, etc.; but no detailed estimate can be made without an exhaustive survey. This I would recommend, and also a systematic gauging of the different streams during the coming dry season, and an analysis of the waters once a month.

In making the measurements for area of catchment, etc., I have consulted the maps of the U. S. Coast Survey, and of the U. S. Land Survey; the plan of the survey and proposed line by Mr. Hoadley; the leveling and the transit books of the same; and the manuscript military from the Golden Gate to Monterey, by the late Gen. McPherson.

In this latter map, of which a copy is in the Bureau of Engineers, U. S. A., at Washington, the boldest features of the topography are well exhibited.

A copy of Prof. Whitney's geological and topographical map of this region, is annexed to this report, in addition to the maps and plans of Mr. Hoadley.

The generalizations of this report necessarily result from the want of the usual materials of detailed surveys and special examinations. But, from my own knowledge of the country and its sea-board climate, I believe the proposed sources of supply on the Peninsula of San Francisco, are the most unfailing within practicable engineering distance; that they furnish an adequate supply, even in the driest seasons, for a population of over one mil-

lion people ; that the supply can be largely increased from more southern parts of the Peninsula ; and that the works of engineering are not difficult.

Very respectfully yours,

(Signed), GEO. DAVIDSON.

Report of the Special Committee

TO THE

BOARD OF SUPERVISORS;

TOGETHER WITH

Communications of Gen. B. S. Alexander, U. S. A. and Professor George Davidson, U. S. C. S.

ON THE

WATER SUPPLIES

For the City of San Francisco.

REPORT.

To the Hon. the Board of Supervisors
of the City and County of San Francisco:

The Special Committee on Water Supply appointed April 10th last, to whom were referred the propositions of various parties to furnish this City a supply of fresh water, have the honor to submit their report.

In prosecuting their investigations, your Committee have considered particularly the two important objects as equal, viz:

First, to secure an abundant, unfailing, available supply of pure fresh water— ample to provide for the wants of our rapidly increasing population—say for the next fifty years; and, Second, to be able to utilize and introduce into this City the supply required, at the lowest possible cost, that it may come within the reach of all classes to enjoy the blessing of plenty of good, pure water, at a nominal price.

Clear Lake.

Your Committee, in beginning their labors, first visited Clear Lake, in the month of June last. It is a grand body of water with an area of eighty square miles, and at that time afforded a vast amount of supply at an elevation of 1,500 feet above the tide level. This large flow, we have been informed, varies but little at any time except in the rainy season, when it is largely increased.

According to the reports of their Engineer, the Company consider it practicable to introduce an abundant supply into this City at a reasonable cost.

Cause of Delay in Reporting.

In order to view the waterflow of the streams of this Peninsula at their lowest stage, your Committee deferred their examinations to the latest days of the dry season ; which will excuse their delay in presenting this report.

The two successive years of severe drought—with a previous year of less than average rainfall—which our State has passed through, had reduced the waterflow of all springs and running streams to an uncommonly low stage, consequently we have had opportunity for making our examinations at a minimum flow, unprecedently favorable for basing an estimate of minimum supply of living water.

Lake Schemes.

The various projects submitted to your honorable body for introducing water into this city, from the lakes of the Sierras, possess the one prominent feature of an unlimited source of supply, and it is also urged that these lakes, fed by the drainage of the snow-belt, afford water of a purer quality than ordinary. While admitting the first proposition (but perhaps not the second), your Committee believe that the great distance of these water sources from this city, would so increase the cost of a proper and permanent system of works of required capacity to imtroduce the adequate supply, as to defeat the grand object of securing such supply at a reasonable cost. The tax upon the enormous cost of an extended line of works necessary to carry out some of the stupendous schemes proposed, would be excessive and burdensome upon our population.

Lake Tahoe.

The Lake Tahoe project in particular embraces a scheme of tunnelling at the outstart, to tap the proposed supply of water, nearly equal in magnitude to the famous Mont Cenis Tunnel under the Alps, which has cost about $15,000.000, and required fourteen years of active work, backed by the cheap labor and mechanical resources of two great nations to complete. Such a scheme as this for our water supply has been well referred to as "chimerical;" and when we further consider that this costly mountain labor—for which this city has been modestly requested to pay $6,000,000 as a starter, with the prospect of having the privilege of paying unlimited millions more in future to keep the ball in motion—is to bring us forth a veritable mouse of twenty millions gallons of water for our people as the projectors may see fit to supply, it may deserve a harsher epithet.

Disadvantages of seeking a Water Supply from very Distant Sources.

Another important question for consideration is the risk of frequent interruptions of the water supply from sources so distant, requiring so long a line of works, crossing in their route as projected, broad plains, large rivers, and our still larger bay.

In this connection we think it may not be improper for us to quote from the report of the Royal Commissioners, on the water supply of London, page 126, which says:

"As to the plans for obtaining water from the mountainous districts of England and Wales, we are of opinion that Mr. Bateman's scheme is, in an engineering point of view, feasible and practicable, and that by it a large supply of water might be obtained for the metropolis,

but that experience warrants great caution in judging of the sufficiency of a gravitation scheme of such magnitude.

"That the quality of the water would be satisfactory as regards its purity.

"That the outlay for the scheme would be very large, amounting, according to the evidence laid before us, to about £11,000,000 ; but in the absence of detailed surveys, and in a project involving works of such magnitude and novelty, and subject to such large contingencies and elements of uncertainty, we do not consider that it is possible to arrive at any trustworthy estimate of the cost.

"That even assuming that the work could be carried out for the estimated amount, the cost to the metropolis of obtaining water by this scheme would be much greater than is incurred by the present plan, and would continue to be so up to any quantity likely to be required within a reasonable lapse of time.

"That grave doubts may be entertained whether it is desirable that the metropolis should be dependent on one source of supply so far removed, and which might be liable to accidental interruption."

"The same reasoning, perhaps slightly modified, will apply to obtaining a water supply from the lakes on the western slope of the Sierras, or the head waters of the American, the Mokelumne and other rivers heading in the Sierra Nevada mountains. *If London with its vast population of nearly four millions of people and its almost fabulous wealth, hesitates to go one and hundred eighty miles for a water supply, how can San Francisco seriously entertain a similar project?*

Water Supply of the Peninsula.

Arguing from these premises, which we believe will be confirmed by the opinions of the best practical en-

gineers, your Committee have felt themselves justified in confining their investigations almost exclusively to this peninsula for the future water supply of this city, and from information obtained from respectable and reliable sources, as well as from such personal examinations as they have been able to make upon their several trips to the various streams as far south as the Pescadero, we are of opinion that the water sources of the peninsula within a reasonable distance, are amply sufficient to furnish an abundant supply of good, pure, fresh water to provide for the wants of San Francisco for at least fifty years. And we believe that thereafter, if it may be found necessary, an extension of the line of then existing works will be practicable to take up the waters of the streams south of the Pescadero, and thereby increase the amount of supply to an almost unlimited extent.

It has been ascertained by levelings made upon the streams, that the supply from the Pescadero and streams north of it can be availed of at a height sufficient to place in storage reservoirs and introduce it thence into the city by natural flow (gravity) at an elevation of at least two hundred and fifty feet.

Storage Reservoirs.

The peculiarity of our climate—with an ordinary dry season of at least six months, sometimes more—and occasionally two or more successive seasons of drought such as we have just experienced, makes apparent the vital necessity of having reservoirs of very large capacity for the storage of the surplus water of our wet seasons.

This peninsula possesses great natural advantages for making such storage reservoirs as will be ample for all the purposes required.

Distributing Reservoirs.

San Francisco has within its corporate limits natural elevated localities admirably suited for large distributing reservoirs.

Rain-fall.

From the register or rain-gouge kept at Pillarcitos, we find that the rain-fall there is far in excess of (sometimes more than double) the amount which our rain-gauges register as falling in this city, and it is reasonable to suppose that the heavily timbered water-shed of the Pescadero and San Gregorio, being of a greater elevation, are blessed with certainly as large, if not a greater rain-fall than the Pillarcitos.

We submit, herewith, a tabular statement of the rain-fall as marked by gauge in this city from 1849 to 1871 inclusive, which may be interesting in this connection :

Rain-fall in San Francisco, Cal., as Recorded by Thomas Tennent, from 1860 *to* 1871.

	1860.		1861.		1862.		1863.		1864.		1865.		1866.		1867.		1868.		1869.		1870.	
	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.
July.....	.21	1	....	..	....	..	....	..	....	..	....	..	....	..	....	..	....	..	....	..	....	..
August. ..	....	..	....	..	....	..	....	..	.21	3	....	.	....	..	....	..	....	..	....	..	....	..
September.	....	..	.02	1	....	..	.03	1	.01	1	24	2	.11	2	.04	1	....	..	.12	1	.03	1
October...	.91	12	....	..	.40	2	....	..	.13	3	.26	4	....	..	.20	1	.15	3	1.29	2	....	..
November.	.58	3	4.10	12	.15	3	2.55	5	6.68	8	4.19	10	3.35	12	3.41	6	1.18	5	1.19	5	.43	4
December..	6.16	21	9.54	16	2.35	9	1.80	8	8.91	18	.58	8	15.16	18	10.69	18	4.34	11	4.31	7	3.38	8
	1861.		**1862.**		**1863.**		**1864.**		**1865.**		**1866.**		**1867.**		**1868.**		**1869.**		**1870.**		**1871.**	
January...	2.47	8	24.36	18	3.63	9	1.83	5	5.14	9	10.88	16	5.16	15	9.50	17	6.35	14	3.89	9	3.07	7
February..	3.72	8	7.53	10	3.19	10	....	..	1.34	8	2.12	9	7.20	9	6.13	9	3.90	5	4.78	9	3.76	10
March.....	4.08	8	2.20	11	2.06	8	1.52	9	.74	4	3.04	12	1.58	7	6.30	12	3.14	12	2.00	8	1.29	8
April.....	.51	4	.73	9	1.61	9	1.57	4	.94	3	.12	1	2.36	8	2.31	9	2.19	5	1.53	4	1.93	5
May.....	1.00	3	.74	5	.23	2	.78	5	.63	2	1.46	6	...	..	.03	2	.08	2	.20	2	.21	3
June.....	.08	2	.05	1	....	..	....	..	....	..	.04	1	....	..	.23	3	.03	1	....	..	....	..
	19.72	70	49.27	83	13.62	52	10.07	38	24.73	59	22 93	69	34.92	71	38.84	78	21.35	58	19.31	47	14.10	46

Average Rain-fall from the season of 1849–50, to that of 1870–71—22 Seasons—23.5 inches.

No. 1.

Rain-fall in San Francisco, Cal., as Recorded by Thomas Tennent, from 1849 *to* 1860.

	1849.		1850.		1851.		1852.		1853.		1854.		1855.		1856.		1857.		1858.		1859.	
	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.	Quantity.	Days.
July	...	..	....	..	....	..	....	..	....	..	....	..	....	..	.02	1	....	..	.05	2	....	..
August	...	..	....	..	....	..	....	..	.04	1	.01	1	....	..	....	..	.05	2	.16	2	.02	1
September	....	..	....	..	1.03	1	....	..	.46	4	.15	3	....	..	.07	2	....	..	....	..	.03	1
October	3.14	3	....	..	.21	2	.80	1	.12	2	2.41	9	....	..	.45	5	.94	3	2.74	4	.05	1
November	8.66	8	1.25	6	2.12	5	5 31	12	2.28	12	.34	2	.67	7	2 79	9	3.01	11	.69	5	7.28	15
December	6.20	12	1.05	4	7.10	14	13.20	20	2.32	11	.81	3	5.76	15	3.75	12	4.14	8	6.14	14	1.57	5
	1850.		**1851.**		**1852.**		**1853.**		**1854.**		**1855.**		**1856.**		**1857.**		**1858.**		**1859.**		**1860.**	
January	8.34	15	0.72	5	.54	4	3.92	11	3.88	10	3.67	11	9.40	13	2.45	7	4.36	8	1.28	5	1.64	8
February	1.77	5	0.54	4	.14	4	1.42	5	8.04	16	4.77	10	.50	4	8.59	15	1.83	8	6.32	18	1.60	7
March	4.53	7	1.94	9	6.68	14	4.86	6	3.51	11	4 64	12	1.60	5	1.62	6	5.55	8	3.02	11	3.99	13
April	0.46	3	1.23	8	.26	3	5.37	8	3.12	9	5.00	10	2.94	6	....	..	1.55	4	.27	4	3.14	8
May	....	..	0.67	3	.32	1	.38	7	.02	1	1.88	6	.76	3	.02	3	.34	3	1.55	4	2.86	11
June	....	..	....	..	...	..	....	..	.08	2	....	..	.03	1	.12	1	.05	1	....	..	.09	2
	33.10	53	7.40	39	18.44	48	35.26	70	23.87	79	23.68	67	21.66	54	19 81	61	21.88	56	22.22	68	22.27	73

Accurate Survey required to give Accurate Estimates of the Cost of Works.

In regard to the cost of a proper system of works necessary to supply this city for the future from the water sources of this peninsula, your Committee feel themselves unable to give an accurate estimate. In order to arrive at any intelligent conclusion on these points, a detailed examination and survey of the route made by competent engineers for this especial purpose, will be necessary, who can then estimate in full and give all required information on the subject with certainty.

In arriving at our conclusions, we did not feel willing to depend entirely upon our own judgment in deciding on this important question of such great public interest, and therefore, without authority from your Honorable Body, have called upon General B. S. Alexander, U. S. A., of the Corps of Engineers of the Pacific Coast, as also on Prof. George Davidson, of the United States Coast Survey, who accompanied us upon our several trips of investigation on the Peninsula, and we submit herewith their communications on the subject in reply to letters addressed to them by us (Nos. 1, 2, 3, 4,) to form a part of this report.

Data of Water Supply to various Cities.— Approximate.

Your Committee have endeavored to procure all the reliable information possible in regard to the water supply of the largest cities in the United States and England, and we give herewith a tabular statement (approximate) of some of the most important points of interest, especially as connected with capacity of daily supply and average number of gallons delivered daily, per capita :

Name of City.	Source of Supply.	Length of Line, miles.	Height above city, feet.	Class of Works.	Gallons delivered daily.	Inhabitants.	Daily delivery per head.
New York.....	Croton River	42½	160	Gravity...	85,000,000	942,541	85
Boston.....	Lake Cochituate....	14¾	136	Gravity...	15,000,000	250,526	60
Philadelphia. ..	Schuylkill River....	1	150	Pumping.	40,000,000	674,022	60
Washington*...	Potomac River.....	18½	147	Pumping.	12,000,000	109,204	110
Chicago	Lake Michigan.....	2	150	Pumping.	15,000,000	298,983	50
London†	River Thames.....			Pumping.	100,000,000	3,100,000	32
Glasglow‡.....	Loch Katrine.	26		Gravity...	25,000,000	500,000	50
Edinburgh	Bevilaw Springs....	8					45
Dublin.							40
San Francisco..	Pillarcitos.....				7,500,000	149,482	50

*A very large amount consumed by government buildings, workshops and fountains.
†Population nearly 4,000,000 at present.
‡In 1868.

London, when she had a population of nearly 3,100,000, received about 100,000,000 gallons daily, or, for each inhabitant thirty-two gallons; Glasgow, fifty gallons; Edinburg, forty-five gallons; Dublin, forty gallons; Philadelphia, sixty gallons; Boston, sixty gallons; New York, eighty-five gallons (supposed); Washington, one hundred and ten gallons (a very large amount being consumed by the government buildings, workshops and fountains.)

What Amount San Francisco will Require.

San Francisco now receives about fifty gallons per head, daily.

On the most liberal scale, allowing that during our dry season—say six months—one hundred gallons per diem per head are used, and during the wet season fifty gallons, an average will be seventy-five gallons. Allow as average seventy-five gallons for each inhabitant—which, of course, would include all water required for our parks, sprinkling streets, flusing sewers, etc. and wastage—works to supply on this scale a population of 1,000,000 inhabitants, should be of capacity to introduce from 60,000,000 to 100,000,000 gallons of water daily.

But it will be many years before San Francisco will have so large a population, or require so large a water

supply, and in building water works now, it does not seem fair to tax the present generation with an outlay to completely provide for the next. This will, however, be regulated by the further extention of the line of works to streams south of the Pescadero, as a large increase of population may demand an increased supply of water in future.

Wastage.

The wastage of water in large cities is very great.

The report of Edward H. Tracy, Esq., Chief Engineer of the Croton Board, to the Commissioner of Public Works, New York, dated April 14th, 1871, on page 108, says :

"We are now delivering 85,000,000 gallons of water into the city every twenty-four hours, which is about eighty-five gallons to each inhabitant. This is a much larger quantity per inhabitant than is furnished by any other large city, and although the numerous manufactories which add to the prosperity of the city absolutely require an enormous amount of water for their necessary operations, still a great and wanton waste is going on, which has been increasing at a greater ratio within the past few years than during any previous time ; and if this waste continues to increase as it has done, the wastage will amount to more water than that necessarily used."

Many expedients have been resorted to in various places which have largely decreased waste.

In the city of London great success has attended these efforts. In any city with a large population—no matter how generously the supply of water is provided—great pains should be taken to prevent waste; and in our State, with its peculiarity of long dry seasons, the necessity for preventing wastage is more apparent.

This opens the question as to the supply—whether the inhabitants shall be allowed to use it at discretion, or through the use of water-meters, which latter method is being adopted with economy in many of our large cities, and is already in use here by large consumers.

The report of the Engineer of the Philadelphia Water Department, for 1869, on page 15, says :

"It is very desirable that the use of (water) meters should be commenced in this city—now the only one of any pretensions where they are not employed. * * * Wherever meters have been introduced they have given satisfaction, not only to the supplier, but to the consumer."

Control of the Water Supply.

That the City should own and have absolute control of the waterworks is a fact self-evident and requires no favorable argument from us. The success and admirable management of the great waterworks of New York, Boston, Philadelphia, Chicago, Washington, and other large cities of our own land, afford satisfactory experience, ample to vindicate its necessity and exediency in our case.

The same question has received the particular consideration of the Royal Commissioners of Water Supply of London, and we think, after the thorough investigation devoted to the subject in London, where the supply is governed by companies, it will not be improper for us to quote from their report. On pp. 120, 122 and 127, they say :

"In a matter of such vital importance to the health of a large population, we consider that it becomes a serious question in what hands the control of the water supply should be placed. The duty of supplying the inhabitants of a city with water has, from an early period, been regarded as a peculiarly municipal function, and the supercession of the municipality by joint stock companies is a comparatively modern innovation * * * * * * * But of late years many towns in England have come to the conclusion that the new practice was a fundamental error, and have resumed the ancient principle by taking the control of the water supply again into their own hands.

"In the first place, such a measure affords, we consider, the only effectual means of carrying out in the metropolis, the system of constant supply. We have stated under the last head that we conceive the difficulties of introducing this system would be too great to be effectually overcome by private companies, inasmuch as the great powers necessary for the purpose could only be confided to some public body, who would be responsible for their proper application.

"Secondly, this measure would offer the best mode of insuring a proper supply of water to the poor, which, as already stated, has been found impracticable under the present system * * * * This measure would much facilitate the provision of water for all public and municipal purposes, and in particular for the important object of extinguishing fires.

"But independent of these advantages, we believe the public management to be far more correct on general principle, than the supply by joint stock organizations * * * * * But a sufficiency of water supply is too important a matter to all classes of the community, to be made dependent on the profits of an association * * We are hence led to the conclusion, that future legislation should restore the ancient practice.

"We are of opinion that it is of vital importance that an abundant supply of water should be provided for all classes of the population, as well as for general public purposes, street watering and cleansing, public fountains, and extinguishing fires That the future control of the water supply should be entrusted to a responsible public body, with powers conferred on them for the purchase and extension of existing works, and for levying the rates referred to."

The above is unmistakable language, and coming from so high a source, where the investigations have been so fully carried on, and based upon the voluminous testimony of the most expert scientific engineers, and the opinions of able practical men, it is deserving of the greatest consideration.

Summary of Conclusions and Recommendations.

In conclusion, your Committee are of opinion: That there is an abundant supply of good fresh water on this peninsula, available at sufficient elevation and within a reasonable distance from this city, to meet all the wants of any population San Francisco will probably have within the next fifty years; and, therefore, it is unnecessary to look for a supply to distant sources, entailing a large outlay, with serious difficulties to overcome, and liable to frequent accidental interruptions.

That the cost of works to introduce the water supply from this Peninsula will not be excessive, but in the absence of any special survey for this purpose, only an ap-

proximate estimate of such cost can now be reached; a detailed survey of route should be made, including the necessary examination of sites for reservoirs; the flow of water from the various streams gauged; plans and specifications of the works prepared, and cost of the right of way and lands required for reservoirs ascertained.

That as an increase of population in future years may demand, the line of works can then be extended to utilize the supply from more distant streams on the Peninsula, so that the present generation will not be taxed to provide water supply for the next.

That the city should own the water-works, and have control of the whole water supply.

That no time should be lost by the city in taking favorable action on this important question of public interest.

That we recommend the city make application to the State Legislature, now in session, to secure the proper legislation, giving authority (to the city) to provide funds to carry out these measures, which we believe are of vital importance to the health and comfort of the people, and necessary to the actual existence of the city itself.

Respectfully submitted,

A. B. Forbes,
Stuart Menzies,
A. Badlam. } Committee.

(No. 1.)

Rooms of the Board of Supervisors,
San Francisco, November 22, 1871.

Gen. B. S. Alexander, U. S. A. Corps of Engineers, Pacific Coast.

Dear Sir:—As you have accompanied us upon two occasions in our trips of examination of the water supply

of the Peninsula of San Francisco as far south as the Pescadero, we take occasion to ask your opinion in writing (in so far as you may have formed one from observations) on the following points:

First.—As to the question of their being an abundant, unfailing and available supply of good fresh water on this Peninsula, for the present requirements of this city.

Second.—As to the future sufficiency of the supply from the same source, taking into consideration the probable increase of population of this city to one and one half millions of people.

Third.—If such sufficient supply of water exists, please give your views as to the most desirable and economical mode of introducing it into the city, having in view at the same time a system of works that will be of permanent character in all respects for the future.

Fourth.—Although aware that the limited examinations we have made of the ground and line are insufficient to form any accurate detailed estimate of the cost of the whole work, yet your long experience as an engineer will enable you to take a comprehensive view of the matter and form an approximate estimate, and we would therefore be pleased to have your views on this subject also.

Fifth.—We should be also pleased to have your views and suggestions upon any other points connected with the whole question of the water supply of this city, that you may deem important and pertinent.

Yours, very respectfully,

[Signed] A. B. Forbes,
S. Menzies,
A. Baldlam,
Committee appointed by the Board of Supervisors.

(No. 2.)

SAN FRANCISCO, Cal., December 1, 1871.

Messrs. A. B. FORBES, S. MENZIES, A. BADLAM, Committee of Board of Supervisors.

Gentlemen: I have duly considered your letter of the 22d ultimo, in which you ask me sundry questions in relation to the water supply of this city, and I now proceed to answer them.

I take them up in the order in which they were propounded.

"*First—As to the question of there being an abundant, unfailing and available supply of good fresh water on this Peninsula for the present requirements of this city.*"

To a proper answer to this and your other questions, it is necessary to state what the available water supply of this Peninsula is.

I do not propose to go into any theoretical discussion as to the amount of rain-fall and evaporation on the different portions of the Peninsula, or of the precise proportion of the rain-fall which may be made available. These subjects have been discussed before, and you are already fully informed in relation to them. I prefer to treat this question more practically, and draw my results, whatever they may be, from experience. And fortunately we are not entirely without experience on the subject.

The water that the city has obtained from the Pillarcitos reservoir for several years furnishes us with precisely the data we want.

This is a reservoir of the capacity of 1,050,000,000 gallons, obtained from a water-shed of 3,200 acres, or of five square miles.

This reservoir supplied the city during the year 1869 with 1,346,000,000 gallons; during the year 1870 with 1,547,000,000 gallons; total, 2,893,000,000 gallons; the the average for the two years is 1,446,000,000 gallons.

This amount of water spread out over the entire area of five square miles would cover it to a depth of about seventeen inches. That is to say, let the rain-fall be whatever it may have been, about seventeen inches of it over the entire water-shed supplying the reservoir was made available and actually delivered in the city.

It is true that some of the waters from the Pillarcitos reservoir, in very wet seasons, have occasionally run to waste, and the Spring Valley Water Company are now making the necessary works to store these and other wrters in the large San Andreas reservoir, thereby greatly increasing the available supply for the city.

My object, however, in making this investigation, was to show how much of the rain-fall over the Pillarcitos water-shed had been made available and delivered into this city; for on these data we can base safe conclusions as to what amount of water may be relied upon on the streams south of the Pillarcitos, emptying into the Pacific Ocean.

These streams, as we proceed south, are the Purisima, Tunitas, San Gregorio and branches, and the Pescadero, with perhaps others still further south.

It is believed from the configuration of the country, though no rain-gauges have been kept there, that the down-fall of rain on the watersheds of these creeks is as great as at Pillarcitos, and that the available catchment would also be as great if proper works were constructed to store and carry away their waters, and I shall proceed on this supposition.

Now, as you know, a preliminary survey has been made by the San Francisco Water Company, starting at the head waters of the Pescadero, for a line of conduit picking up the heads or available waters of the other streams, with the view of bringing all their waters to this city at some future day.

We are enabled, therefore, from the maps, to estimate, approximately, the available area of catchment of each of these streams above the line of the proposed conduit. They are as follows: Pescadero, thirty square miles; San Gregorio and branches, twenty-four square miles; Tunitas, six square miles; in all, sixty square miles. I have omitted the Purisima, because it is said that its waters are impure.

Here we see that we have an available watershed on the streams flowing into the Pacific Ocean, north of the Pescadero, twelve times as large as that of the present Pillarcitos reservoir.

If, therefore, the Pillarcitos reservoir can furnish the city with 1,446,000,000 gallons of water yearly, these creeks could furnish twelve times as much, or 17,352,000,000 gallons; add Pallarcitos, 1,446,000,000 gallons; and San Andreas reservoir, say equal to Pillarcitos, 1,446,000,000 gallons, and we have 20,244,000,000 gallons.

But this is not all. If the proposed conduit crosses the dividing ridge and enters the Cañada de Reymundo, its watershed of about eighteen square miles will at once become available. The downfall of rain is much less here, and the available catchment would also be less For safety, we may assume it to be one third of what it is on the western slope.

This would then add 1,735,000,000 gallons more; making in all 21,979,000,000 gallons yearly, or a daily supply of 60,216,438 gallons.

Enough, certainly, for the present wants of the city, for it is a quantity from six to eight times the supply now furnished from all sources, including that obtained from Lobos Creek.

"*Second—As to the future sufficiency of the supply from the same source, taking into consideration the probable increase of population of this city to* 1,000,000 *or* 1,500,000 *people.*"

The figures given in answer to your first question, give the data for answering your second.

60,000,000 gallons daily would give 1,000,000 of people a daily supply of sixty gallons each. If the population of the city should increase to 1,500,000 persons, they would only get forty gallons of water each daily, from the sources I have enumerated.

What the future Waterworks should be.

"*Third—If such sufficient supply of water exists, please give your views as to the most desirable and economical mode of introducing it into the City, having in view at the same time a system of works that will be of permanent character in all respects for the future.*"

It is impossible to answer, in detail such a question as this, without an elaborate and careful survey made for the special purpose of furnishing the necessary information upon which to form opinions and base plans.

Omitting specifications for the present, there are nevertheless certain general considerations that should always be kept in view, however the details of the plans may be varied.

One of these is that we must have large storage reservoirs to store a very large quantity of water, if possible a a year's supply, to guard against a succession of dry seasons.

2. We must have reservoirs at the Tunitas, at the San Gregorio and at the Pescadero, in order to be enabled to hold the waters of these streams in check in times of flood, until our conduit shall have time to carry their waters to the proper storage reservoirs. You will want the flood waters of these creeks just as much as the Spring Valley Water Company wants the flood waters of the Pillarcitos.

3. If such a water supply is undertaken, the works connected with it should be made permanent. In my

judgment a masonry conduit will be preferable to iron pipes.

4. I think the Cañada de Raymundo probably affords the best location for the large storage reservoirs, although there are other places that might be selected for this purpose. In fact it is possible that detailed surveys my discover even better locations than this Cañada.

5. Let us suppose that this Cañada is selected for the sites of the storage reservoirs; then I am of the opinion that the diameter of the conduit entering it should not be less than ten feet. This size should continue until it takes up the waters of the Tunitas. Between the Tunitas and the first branch of the San Gregorio it might be slightly decreased, and go on decreasing as the several streams are taken in, leaving the San Gregorio Valley with a diameter of perhaps eight feet, and continued this size until the waters of the Pescadero are taken up.

Although the Pescadero, in times of heavy rains, will flow much more than sufficient water for a conduit of this size, yet with an inexpensive reservoir there, we can hold back the waters of even a week's flood until such a conduit could discharge them into the storage reservoirs.

Besides, by having the conduit of this size it would be sufficiently large to be extended, when the increased population of the City may demand it, to the head waters of the San Lorenzo, and possibly to other streams in the Santa Cruz Mountains.

The preliminary survey I have mentioned fixes the level of the water surface in the reservoir at Percadero at thee hundred and ninety-four feet above tide, and the distance thence to the Cañada de Raymundo at twenty-five miles.

With a slope to the conduit, therefore, of two feet per mile the water may be delivered into reservoirs at this

Cañada (and provide for draining all the small reservoirs on the route), at a height of fully three hundred feet above tide, and into the distributing reservoirs in the City limits at a height of about two hundred and fifty feet above tide.

The Approximate Cost.

"*Fourth—Although aware that the limited examinations we have made of the ground and line are insufficient to form any accurate detailed estimate of the cost of the whole work, yet your long experience as an engineer will enable you to take a comprehensive view of the matter, and to form an approximate estimate, and we would therefore be pleased to have your views on this subject also.*"

Here again we are met with the want of exact information to form a correct estimate of the cost of such works.

We do not know exactly the location of the conduit, nor its length; we do not know how much tunnelling, or how much filling; nor do we know the number, or even the location of our storage and distributing reservoirs.

Without details it is always well, in undertaking to form an estimate, to be governed by experience.

We have much experience in the construction of water-works in this State; consisting of flumes, ditches, pipes and tunnels, but there are no works on this coast of the kind here contemplated. If we go east for information, the prices will not be the same there.

However, we find that New York City, Boston and Washington, all have brick conduits bringing water into them.

The Croton Aqueduct, in New York, is forty-five miles long; cost, when first built, $12,000,000; capacity, 30,000,000 gallons daily. Therefore, each dollar of capital expended will bring two and a half gallons of water per day for centuries.

The Cochituate Waterworks of Boston: conduit, twenty miles long; cost, when first completed, $5,000,000; capacity, 10,000,000 gallons daily. Each dollar of capital expended delivered, therefore, two gallons of water daily.

Potomac Aqueduct, Washington: conduit, thirteen miles long; cost, $4,000,000; capacity, 96,000,000 gallons daily. Each dollar of capital expended, therefore, delivered twenty-four gallons of water daily.

We see by this that the larger the conduit the greater is the quantity of water which each dollar of capital expended will deliver.

Any other inference drawn from these statements as applied to the cost of the new waterworks for this city might be open to criticism.

Nevertheless, from my intimate acquaintance with these works, and with those of many others in this country, I am of the opinion—with a full knowledge of the changed circumstances out here, the increased cost of money and of labor, and the different nature of the proposed works—that the cost of bringing the waters of the Pescadero and the intermediate streams into distributing reservoirs within the city limits, in a conduit of the most substantial construction, can be effected for a sum not exceeding $15,000,000.

When I first looked at the ground over which the proposed conduit must pass, and learned the probable amount of tunneling—some 96,000 feet—I was startled. I feared that the question of cost would prove insurmountable. But when I learned that this was divided among twenty-seven different tunnels, affording, therefore, no less than fifty-four places where this work can be carried on at the same time, the difficulties of this portion of the work partially disappeared; and when I came to examine the character of the rock through which the tunnels will

pierce the spurs of the hills—a soft sandstone easily cut with a knife or worked with a pick—they were entirely removed.

I believe the tunnels, in most cases, may be cut to the exact shape required for the conduit, without the use of powder, and if so, a lineage of a single brick will be all that will be required to afford complete security to the water way.

The tunnelling difficulty being disposed of, all the rest of the work will be of the simplest character. There will be no costly masonry constructions such as the Beacon Hill reservoir in Boston, the Harlem Bridge in New York, or the Cabin John's Bridge in Washington, the longest masonry arch in the world.

The Necessity for Works of Ample Size.

"*Fifth—We would also be pleased to have your views and suggestions upon any other points connected with the whole question of the water supply of this city that you may deem important and pertinent.*"

I do not know that I can suggest anything new under this head. But, in justification of the large sized conduit which I have proposed, and the very large storage reservoirs—larger than any others with which I am acquainted—I will remark that nearly all the water-works that have been constructed for supplying American cities with water, have been designed on an inadequate scale.

New York, Boston and Philadelphia fear a drought of even a few months, although their water works are comparatively new.

The growth of our cities has outstripped all experience derived from Europe, upon which hydraulic engineers had based their calculations.

The quantity of water used by each person has also gone far beyond all former calculations. People in our

American cities look upon water as a necessity, not merely a luxury, and the consequence is they use it lavishly.

Hence it is that the works designed by engineers, and opposed in their inception as being extravagant, have almost invariably failed, within a few years after their completion, to supply the wants of the cities for which they were built.

Let San Francisco learn a lesson from this experience. If she goes after water on this Peninsula, let her construct a conduit and build reservoirs that will enable her to bring enough of it to her doors.

If it be determined by the city authorities to obtain an additional supply of water from this Peninsula, the proper course to be pursued appears to me to be :

1. To procure the proper legislative enactments on the subject.

2. To have the necessary surveys made, contouring the ground for some distance to the right and left of the proposed route of the conduit, and contouring the ground within and around all reservoirs.

3. To guage all the streams, and ascertain the amount of water which they would deliver, at the point where they would discharge into the conduit, for each day of one entire year.

4. Then to have the plans and specifications of the entire works prepared and approved by the proper authorities.

5. In the meantime, the right of way, and all lands necessary to be held by the city in connection with the works should be obtained, either by purchase or condemnation.

6. The work proper might be commenced as soon as the financial condition of the city would justify it.

I think the first work to be done should be to construct the conduit from the Pescadero to the great storage reservoirs, and the reservoirs themselves.

If the water was once there in store, the city could draw upon it as fast as she wanted it, without incurring any great expense to complete all the works in the first instance, leading from the reservoirs to the city.

Thus: the water could be brought from the storage reservoirs to the city in iron pipes. Perhaps it will, on the whole, be better to bring it in pipes. Now, it would require as many as four pipes of four feet diameter to bring into the city all the water that might be wanted at any one time in the distant future, when the population has increased to a million. But one of these pipes would be all that would be required for some years. The cost of the other three would therefore be saved for the time being.

I beg leave to remark, in conclusion, that the cities of California want more water, on account of the long dry seasons, than cities of equal size on the Atlantic Coast or the Mississippi basin.

San Francisco in particular ought to have an abundant supply, in order to keep down the sands with which the streets below and the air above are infested in the Summer season.

She wants enough to flush the street gutters and sewers, and remove all offensive offal from the limits of the city, washing into the bay these offensive and fruitful sources of disease and death; and then when her streets are cleansed, she wants enough water to sprinkle them daily, and hourly when necessary.

Besides, she wants water for the irrigation of Public Parks and private grounds.

The comforts of a city residence depend, to a great extent, on the cleanliness of the streets and the beauty of public parks and private lawns.

The growth of a city and the value of its property, also depend on these things to an extent that can scarcely be over estimated.

New York city felt its influence the day the Croton Waterworks were completed.

Let San Francisco obtain for herself an abundant supply of good, wholesome, fresh water—one hundred gallons for each inhabitant daily—and the diminished rates of insurance, the increased comfort of living, the new demand for houses and lots, and the increased value of property will be such, that none of her citizens will be found willing to forego its advantages for the relief it might afford from taxation.

Very respectfully, your ob't serv't,

B. S. ALEXANDER,

Lieut.-Col. of Engineers, Brev't Brig.-Gen., U. S. A.

(No. 3.)

ROOMS OF THE BOARD OF SUPERVISORS,
San Francisco, Nov. 22, 1871.

PROFESSOR GEORGE DAVIDSON, Superintendent U. S. Coast Survey, Present:

Dear Sir:—The undersigned Committee of the Board of Supervisors, appointed to examine and report on the subject of water supply for the city, are informed that you made an examination of the sources of water supply on this Peninsula in 1869. As the question of future water supply of San Francisco is one of great import, we desire to procure all the reliable information we can on the subject, and therefore respectfully ask you to give us the result of your examination above referred to, and as you have accompanied us on two occasions in our recent examinations of the water sources of the Pescadero, San Gregorio, and other streams on the Peninsula, will you also please state whether your conclusions arrived at in

1869, have been in any way changed or modified by the examinations of 1871.

We will also be pleased to have your views and suggestions upon any other points connected with the whole question of the water supply of this city, which you may deem important and pertinent.

Yours, very respectfully,

[Signed.] A. B. Forbes, S. Menzies, A. Badlam. } Committee.

(No. 4.)

San Francisco, Cal., December 4th, 1871.

Messrs. Forbes, Menzies and Badlam, Committee.

Gentlemen:—I have your letter of the 22d ultimo, in relation to the water supply of San Francisco, asking the conclusions I have arrived at in my recent examinations on the San Andreas, Pillarcitos, Pescadero, San Gregorio, Cañada de Raymundo, etc.; and whether the opinions I expressed after my examination of the Peninsula of San Francisco in the Spring of 1869 have been changed. (Report to the San Francisco Water Company, April 1869) In reply thereto I state that the recent examination has not changed my views, but has confirmed them.

I believe there is an adequate supply of good water on this peninsula for a city of one million inhabitants; that it is within reasonable distance; that there are no grave engineering difficulties to its introduction; that the cost will not be excessive; that a great storage reservoir will be necessary, and that such reservoir can be had with the necessary elevation to deliver water in the city at about two hundred and fifty feet above the level of the Bay.

No close estimate can be made of the cost of the aqueduct to the great reservoir; nor of the cost of mak-

ing that reservoir available, until minute and detailed surveys are made.

An important point for consideration in an extended and extensive supply on this peninsula is the fact that it may be used in conjunction with the existing supply and works.

An argument that should not be overlooked in this question of supply may be based upon this proposition: If the present supply of water to the City from an area of catchment of about seven square miles is adequate for a population of 200,000 people, the supply from an area of catchment of seventy-eight square miles (sixty square miles of which has a greater rain-fall than over the present area of catchment) will be adequate for a population of about 2,000,000.

Yours, respectfully,

GEORGE DAVIDSON.

REPORT

TO THE

SAN FRANCISCO WATER COMPANY,

IN RELATION TO THE

WATER SUPPLY OF SAN FRANCISCO,

By Milo Hoadley,

ENGINEER OF THE SAN FRANCISCO WATER COMPANY.

To the President and Directors of the San Francisco Water Company :

Having secured title to some of the most important lands embraced in our enterprise, it was thought expedient to make a more detailed and extended survey of the lands and waters at our proposed source of supply. With this object in view, a party was organized on the 21st November last, with Col. Wm. S. Watson on the transit, and necessary chainmen, rodmen and axemen.

Our field work was commenced on the 23d November, the first work was to establish the section lines, and fractional parts of sections, to show the locations and connections of our proposed works.

Having extended this as far as was thought necessary, we next ran contour lines through and around the valley, and up the main Pescadero, Peters fork, and other branches at an elevation of 410 feet above mean high tide, which point of elevation had been previously determined. Our survey extended nearly two miles along the main Pescadero, and on both sides, until reaching the bed of the creek on that level, and one-and-a-half miles up Peters fork to an elevotion of 500 feet above the same base. This survey was continued a short distance further in this direction, to show the location of Paige's mill and village. The accompanying map will show the area of flowage to the elevation of the before-mentioned 410 feet.

While the above work was progressing, Captain A.W. Chase, of the United States Coast Survey, with the necessary assistants, made a topographical survey of 2,000

feet, by 2,500 feet covering the proposed locations and selections of the required dam. His map of the same shows the lines of every ten feet of elevation from which the cheapest and most suitable location for the said dam can be determined, as well as the approximate amount of earth, and other work and the cost of the same. It will be recollected that my report of cost, etc., of the proposed work made in November 1867, (from surveys just then completed), the estimates were based on the proposition to furnish but 30,000,000 gallons daily.

In view of the great and growing demands of this city, and the capacity of our sources of supply to meet the same, the present estimates are based on a daily average supply of 75,000,000 gallons, with reserve sources whenever more shall be needed in the future.

During the past summer, several gaugings of the water in Pescadero were made, the lowest point reached being in September, showing a daily flowage of 4,752,000 gallons.

This volume was more than doubled at the time the survey was commenced, after a few light rains, aggregating $3\frac{1}{2}$ inches of rain-fall. From the 17th to the 31st December, the rain-fall at Camp No. 1, was 36.8 inches, and during the greater portion of this time the Pescadero had a volume of over 300,000,000 gallons daily. The entire fall for the season to the 10th instant, was 44.8 inches.

The average daily discharge of the Pescadero may be safely estimated at 50,000,000 gallons. It will be remembered that this stream is less than half of the average source of supply claimed by our Company.

Our surveys have shown a better place for the proposed dam, about 1,000 feet down the stream from the point first selected, and increasing the area of flowage nearly 23 acres. The dam at this point will be 90 feet

perpendicular height from the bed of the creek,with the top 420 feet above tide level , the banks being very preciptious, the top line will be but 505 feet in length.

The area of flowage is estimated at 410 feet, the line on which the contour was run, and amounts to 110 acres, which, with 20 feet draw, has a capacity of 598,950,000 imperial gallons. The dam can easily and safely be raised 30 feet higher, and would then contain approximately, 3,000,000,000 gallons.

This would act as an equalizing reservoir, retaining the great body of winter floods to be passed through the aqueduct as the flow of water subsides.

The water of this creek especially, is of the best quality, drawing its supply from thirty square miles of heavy forest, preventing the rapid discharge of its waters during heavy rains, and retarding evaporation in summer. The percentage of evaporation along the whole coast is nominal, owing to the heavy fogs prevailing during the summer months.

The following estimates are presented as an approximation to the cost of the entire work on the scale now contemplated.

No estimates are made for clearing, as the value of the wood and timber, would much exceed the cost of removal.

The first item, land, damages, and right of way, etc., including the great reservoir, may be safely set down at	$ 650,000 00
Dam at Pescadero with over-fall 100 feet wide, and gates	95,000 00
Five dams on the San Gregoria and branches, average $10,000	50,000 00
Twenty-two miles aqueduct, average $20 per foot	2,223,200 00
Dam at great reservoir	300,000 00

Thirteen miles of wrought iron pipe of 50,000,000 gallons capacity laid down from great reservoir to the limits of this county, at a suitable place for a large distributing reservoir	1,300,000 00
Workmen's buildings, etc	20,000 00
Engineering and Superintendence	100,000 00
	$4,738,200 00
Ten per cent. for contingencies	473,820 00
	$5,212,020 00

On the 11th of December, the survey for the great reservoir was commenced with a view to ascertain its capacity, which was interrupted by storms on the 18th, and we have been unable to resume work since that time. Enough has been done to form some judgment as to its capacity for a great storage reservoir, not alone sufficient for the present and future wants of San Francisco, but for the whole country, from Redwood City to the northern extremity of this peninsula.

This reservoir would hold not less than 30,000,000,000 gallons, and would forever remain pure and sweet, from the constant supply of not less than 10,000,000 gallons daily in the driest season, but from its great depth would purify the water, as it would have a depth of 100 feet over a large portion of the area, below the draw level.

We propose when the weather is settled, to complete the surveys for the great reservoir, when a more accurate estimate of cost and capacity will be submitted.

MILO HOADLEY,

Engineer San Francisco Water Company.

JANUARY 13TH, 1872.

ENGINEER'S REPORT

OF

Detailed Survey of the Great Storage Reservoir,

AT

CAÑADA RAYMUNDO.

To the President and Directors of the
San Francisco Water Company:

In my report of the 13th ult., I proposed to continue the further survey of the great storage reservoir as soon as the weather would permit. This occurred on the 16th ult., or three days after the date of said report.

From that date, our labors in the field were continued, with slight interruptions, for twenty-two working days, or until the 10th inst., with the same parties mentioned in my former report, and the addition of two axemen.

The survey, and accompanying map, show the area of the Crystal Springs valley, on the level of three hundred feet above high tide, with streams, roads, fences, property lines, (where the same would be ascertained), lines of existing water-works, buildings and other improvements.

Crystal Springs valley includes, in its general boundaries, the following valleys and streams: The Cañada San Andreas, the Cañada Raymundo, and its branches, and the valley of San Mateo proper, all uniting below the Crystal Springs Hotel, to form the main San Mateo creek.

Our survey extended from the dam of the Spring Valley Water Company, or San Andreas reservoir, at the northwest, to the southeastern extremity of the Cañada Raymundo, or over nine miles from northwest to southeast, with the San Mateo below the junction nearly one mile, and all the tributaries on either side, up to the contour line, or elevation, before mentioned.

The area contained within the contour line, is seventeen hundred and two acres, and, with a draw of thirty feet, would contain an available supply of thirteen thousand nine hundred and two millions imperial gallons.

The dam at the outlet of the valley would require to be one hundred and sixty feet in height, from the bed of the creek, and would contain, approximately, 900,000 cubic yards of earth.

I submit no new estimates of the cost of construction, or incidentals, as our survey has disclosed a much better location for a dam to form the great storage reservoir, to-wit: the Cañada Raymundo alone.

While the whole valley contains an area of seventeen hundred and two acres, as before stated, the Cañada Raymundo is thought sufficient for the present or future wants of our Company, and the requirements of this city.

This valley, at an elevation of 300 feet above tide, contains an area of nine hundred acres, while, with a further elevation of forty feet, or 340 feet above tide, the area would be largely increased, and probably more than doubled. But, estimated on the area of 900 acres only, with sixty feet draw, it would contain fourteen thousand six hundred and eighty-one millions, or over eighty gallons each per day, for a population of 500,000 inhabitants, for the entire year.

From the limited time allowed, the extent of the line surrounding this valley, the density of the chapparal, and the setting in of stormy weather, the area of a part of this section was computed from triangulation.

I would recommend a full survey of this Cañada, on a level or contour 340 feet above tide, through the Cañada Diablo via Belmont, for the purpose of ascertaining its exact area, the ownership of property and the facility of supplying that locality with water; the said survey to

be delineated on the accompanying map, which is presented in an unfinished form, that other surveys may be attached.

The advantages to be derived from occupying this place as a great storage reservoir are manifold:

First. The land required is comparatively of a poor or worthless character, and is occupied by few valuable improvements.

Second. Our Company would be able to hold and control the entire area of drainage without paying excessive land damages.

Third. There is no interference in any manner with the rights of any other water company, which the occupation of the entire valley would involve—to A. Haywards enterprise supplying San Mateo and the pipes of the Spring Valley Water Company, which would be submerged in two places to the depth of 80 and 100 feet respectively.

Fourth. It would obviate the necessity of purchasing the most valuable land and improvements in the valley, costing hundreds of thousands of dollars.

While most the proprietors are willing or desirous to sell, all are impressed with the belief of its necessity to our Company, and each one thinks his own piece or parcel of land and improvements worth four times as much as any one else estimates it.

Fifth. It would interfere but little with any existing roads or turnpike requiring their restoration at an unknown expense, as the proposed location the Cañada Raymundo would require the construction of but one common road about three miles, at moderate cost.

Sixth. In constructing a dam at the outlet of the Laguna Raymundo by reducing the cost $100,000 and increased security of construction.

The only item in which the expense would be enhanced, is in the increased length of conduit, or pipe, from the reservoir to the city by about four miles.

It will be seen from the before-named propositions and the statements in my report of the 13th ult., that with the reservoir at Pescadero creek having a surface elevation of 420 feet, and a draw of thirty feet, reducing the low water level to 390 feet, with the reservoir at Cañada Raymundo, at an elevation of 340 feet, there would still remain fifty feet fall between them, or six feet more than was estimated in the preliminary survey of this line in 1867. With sixty feet draw on the storage reservoir, reducing it to the level of 280 feet at low water, which point would, in all probability, never be reached, it would still give a fall of thirty feet to the elevation proposed for the distributing reservoir in the city, viz: 250 feet above high tide, or nearly two feet per mile; and, with an iron main to convey the water, all the head in the storage reservoir would be added to the fall, or a head and fall of ninety feet, with both reservoirs full.

While this descent does not pretend to compare with the greater fall or descent in pipes to supply water to the city from more distant and elevated sources, it still is amply sufficient for the purposes required, and exceeds, some of the more important water-works of the United States.

Croton aqueduct, nearly forty miles in length, and with a cross area of fifty-three and one-third feet, has a descent or fall of less than forty-one feet, or a fraction over one foot per mile, and supplies sixty millions imperial gallons per day.

Brookly aqueduct has a fall of six inches per mile, with an open canal, from which the water is raised by steam power to a distributing reservoir on the heights, in the eastern portion of the city.

The Corbituate has a fall of less than four inches per mile, and furnishes a daily supply of 10,000,000 gallons.

It may not be out of place, in this connection, to comment on some of the communications on the subject of water which have appeared in the public prints of this city since the opening of the present session of the Legislature, viz: those signed "*Taxpayer*," which culminated in the especial interest of Clear Lake, and the communications of Col. A. W. Von Schmidt on the Lake Tahoe and San Francisco project.

Without entering into a detailed review of all these articles, it is sufficient to call attention to their more important arguments and deductions:

First. As to the question of evaporation: In a climate where the temperature hardly rises above 60° with a body of water averaging 100 feet in depth, with the prevailing summer fogs, especially in the proposed location for our reservoir, exceeding, if possible, the fogs of this city, the evaporation is nominal.

As a general rule, evaporation is increased by altitude; the greater the elevation, the greater the evaporation.

Second. The whole valley of the Cañada Raymundo has a rock bottom, with permanent springs from every side hill surrounding the basin, entirely preventing the wastage of water by percolation or absorption.

Third. With a constant accession of not less than ten millions of gallons of the purest water, daily, in the driest season of the year, with the extensive area of this storage reservoir, and its great depth, the entire absence of aquatic, or other plants, upon and within its margin, there need be no hesitancy in guaranteeing the perfect purity of its waters.

With an abundant supply of the purest water in the entire coast range, sufficient in quantity for a population of one million inhabitants, and within forty miles of this

city and county, and less than one-fourth the distance to Lake Tahoe, and nearly the same proportion to Clear Lake, by any practicable route ; with entire accessibility to all parts of the works, without the necessity of crossing deep straits or broad bays ; with the entire line on elevated land, thereby lessening the pressure and consequent cost of construction, is it a matter of surprise, that Professor George Davidson, in his report of March 31, 1869, and again, the Committee of the Board of Supervisors, in their report of December last, should characterize the project of bringing water from such distant sources as Clear Lake or Lake Tahoe as "bordering on the chimerical?"

MILO HOADLEY,
Engineer San Francisco Water Company.

FEBRUARY 23, 1872.